



# **Armed Forces College of Medicine AFCM**



# **Bone 1 (Bone Cells)**

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**Histology Department**

# INTENDED LEARNING OBJECTIVES (ILO)



**By the end of this lecture the student will be able to:**

- 1. Describe** the microscopic structure of the bone cells
- 2. Correlate** the structure of the bone cells to their function
- 3. Compare** between different types of bone and cartilage cells
- 4. Interpret** the defect in the microscopic structure of bone cells in different diseases

## Key Points



- Microscopic structure & function of different types of bone cells (osteogenic, osteoblasts, osteocytes & osteoclasts).
- Site, origin & function of matrix vesicles.
- Differentiate between osteoblasts & osteoclasts.
- Differentiate between chondrocytes & osteocytes.
- Diseases which affect bone.

# Bone



## Definition

**Bone is a strong weight bearing form of connective tissue characterized by its solid stony hard intercellula**

## Function

**1)It forms the skeleton of the body.**

**2)It protects the vital organs.**

- Heart and lung in the thoracic cage.
- Brain in the skull.
- Bone marrow in the medullary cavity of long bones.

**3)Has mechanical and metabolic functions ex.**

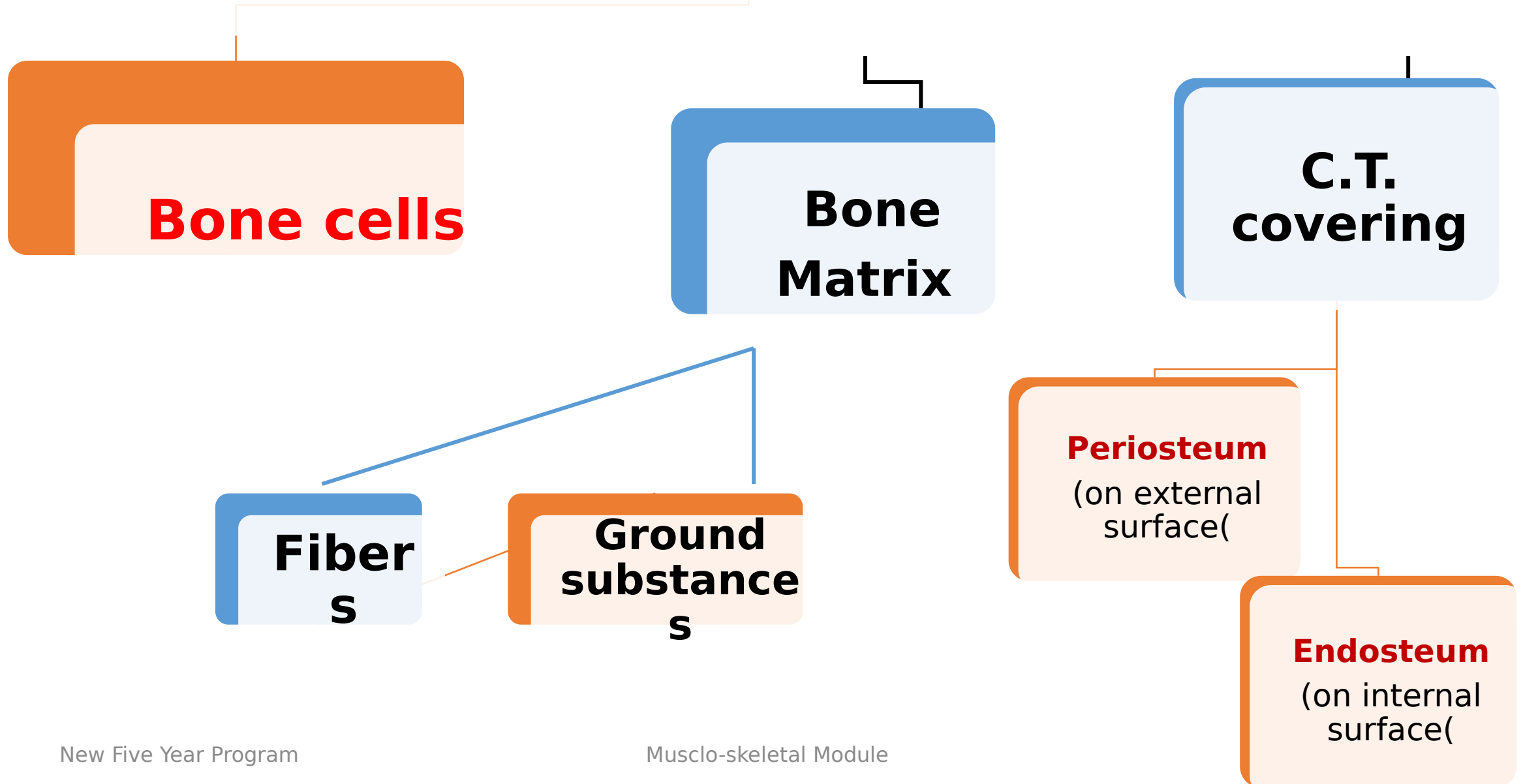
**It acts as a reservoir for calcium.**

**4)It gives attachment to the muscles and tendons.**

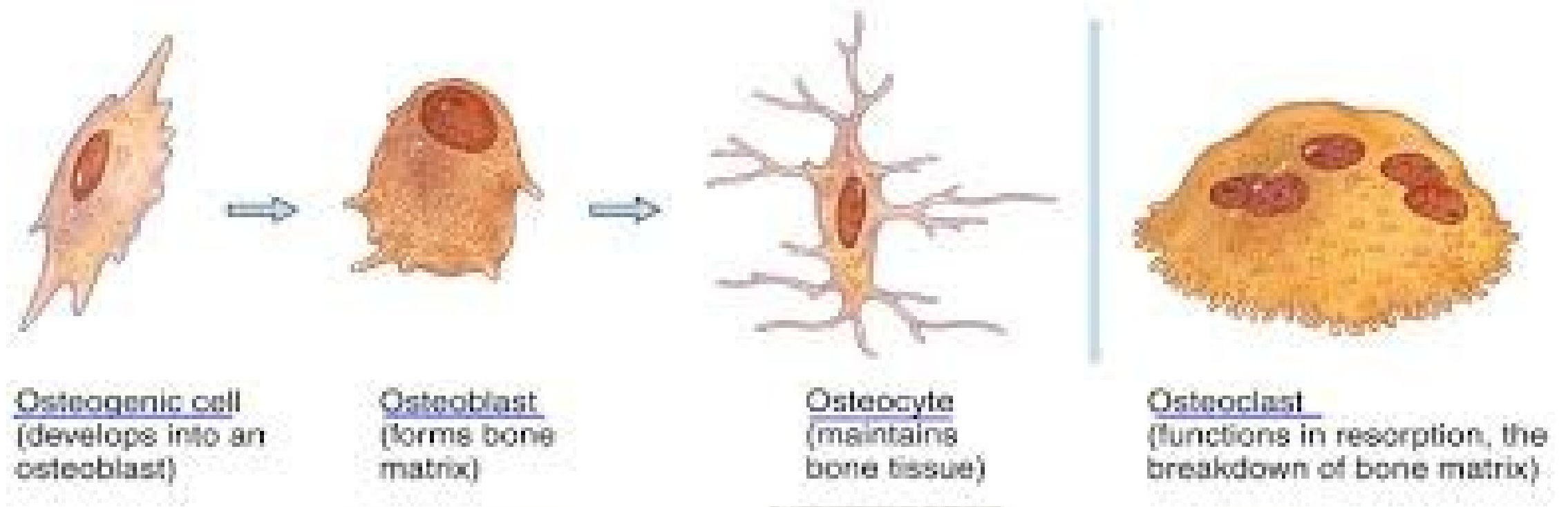


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# Bone consists of:



# Bone Cells



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New Five Year Program

Musculo-skeletal Module

# Bone Cells

## 1)Osteogenic cells:

Origin: UMCs and pericyte.

Site: In the inner osteogenic layer of the **periosteum and the endosteum.**

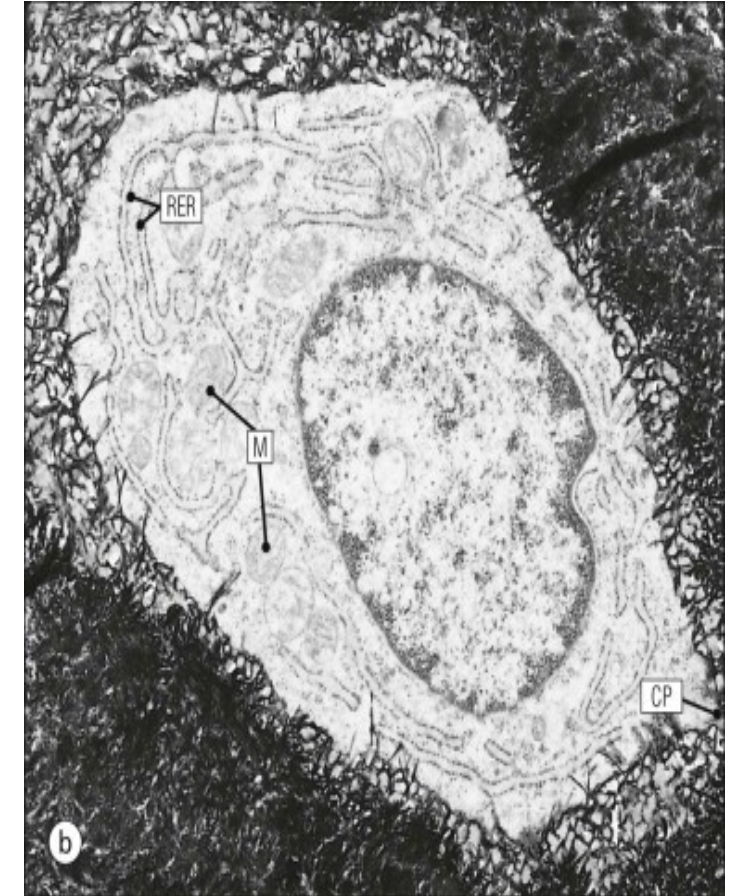
LM:

• Nucleus: central vesicular Cytoplasm: basophilic

E.M: abundant ribosomes, r ER , few Golgi complex, and mitochondria.

Function: They are dividable cells.

- They divide and differentiate into **osteoblasts** in presence of blood vessels and /or good oxygen tension.



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- **In absence of blood vessels and /or low**



# Lecture Quiz



- All the following statements are true concerning osteogenic cells EXCEPT:

- a-They are derived from UMCs.
- ☒ b-Can differentiate to osteoclast
- c-Are found in both periosteum and endosteum
- d-May change into chondroblasts in low oxygen

## 2) Osteoblasts:

**Origin:** mesenchymal stem cells, osteogenic cells (good O2)

**Site:** in the inner osteogenic layer of periosteum and endosteum.

**LM:**

**Shape:** single layer of cuboidal cells.

**Cytoplasm:** deep basophilic, -ve Golgi image near the nucleus (when actively secreting the matrix)

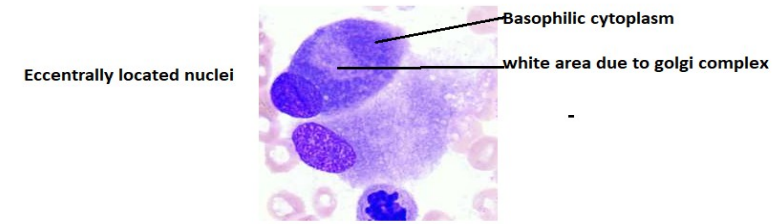
**Nucleus:** vesicular and eccentric.

**E.M:**

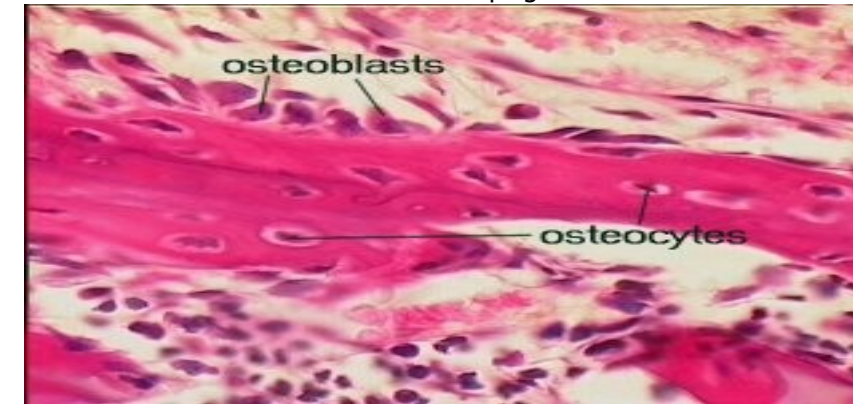
- Ribosomes, rER, Golgi complex, secretory vesicles (matrix vesicles) and mitochondria.

- Cell processes connect one cell to the other and to nearby osteocytes by **Gap**

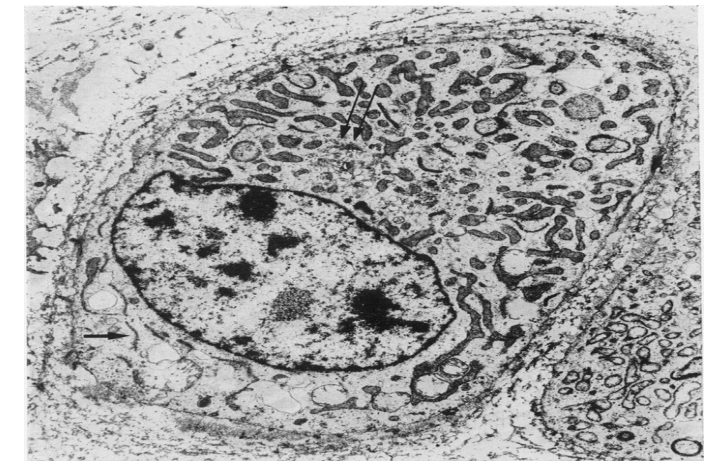
Osteoblast



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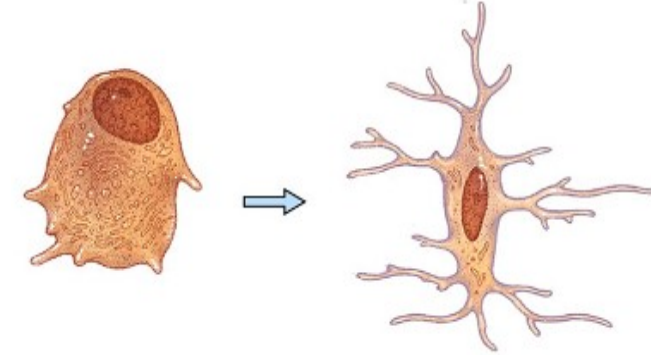
[https://www.researchgate.net/profile/Michele\\_Allouche/publication](https://www.researchgate.net/profile/Michele_Allouche/publication)



## Function: non dividable cells

1) They are responsible for the synthesis and secretion of **organic component** of the **intercellular substance (osteoid tissue)**. Type I collagen fibers, proteoglycans, and (glycoproteins) such as **osteonectin** and **osteocalcin** which binds  $\text{Ca}^{2+}$  ions.

2) **Deposition of the inorganic components of bone.** Osteoblasts release membrane-enclosed **matrix vesicles** rich in **alkaline phosphatase** that raises the local concentration of  $\text{PO}_4$  ions which serve as foci for the formation of **hydroxyapatite crystals**. These crystals grow rapidly by accumulation of more mineral and eventually produce a confluent mass of calcified material.



Osteoblast  
(forms bone matrix)

Osteocyte  
(maintains bone tissue)

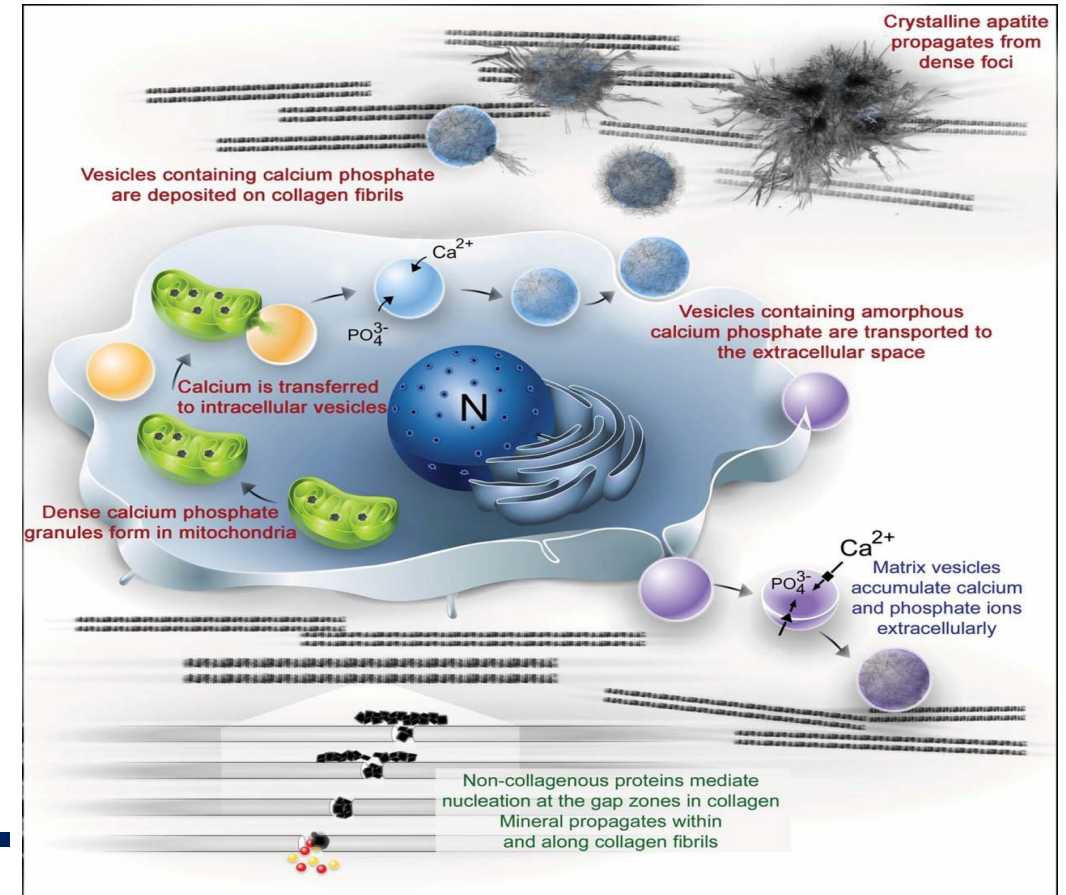
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# Matrix Vesicles



**Site:** small membranous structures in the matrix of cartilage, bone and at any site of calcification.

**Origin:** by budding from the cell membrane of osteoblasts, osteocytes and chondrocytes.



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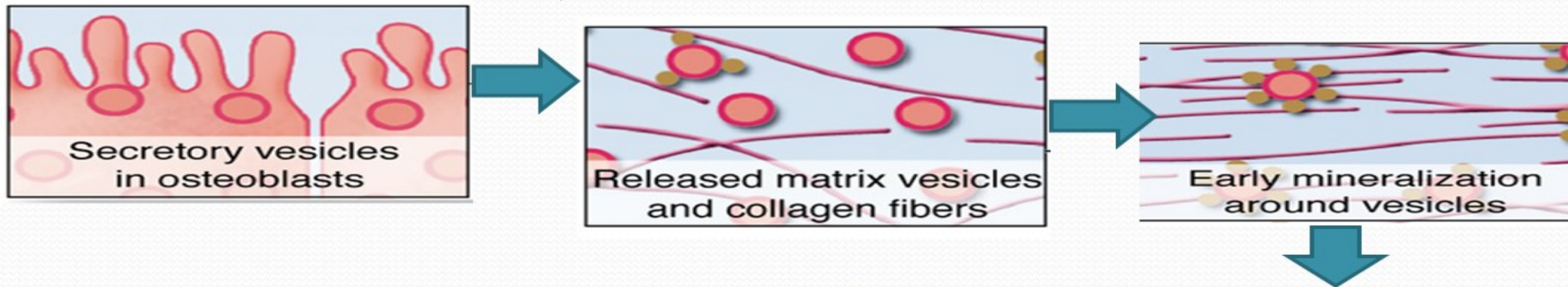


## Function:

**Initiate calcification** of the surrounding tissue by one or both of two mechanisms:-

1. They cause **precipitation of calcium salts** (Ca phosphate) by their content of **alkaline phosphatase enzyme**.

2. They **destroy and inhibit the inhibitors of calcification** by their content of **pyrophosphatase enzyme**.



[https://accessmedicine.mhmedical.com/data/books/2355/janson\\_fig-13-07.png](https://accessmedicine.mhmedical.com/data/books/2355/janson_fig-13-07.png)

# Lecture Quiz



## - Osteoblasts are derived from:

- ☒ a-Osteogenic cells
- b-Chondrocytes
- c-Osteocytes
- d-Osteoclasts

## - All the following are true concerning osteoblasts EXCEPT:

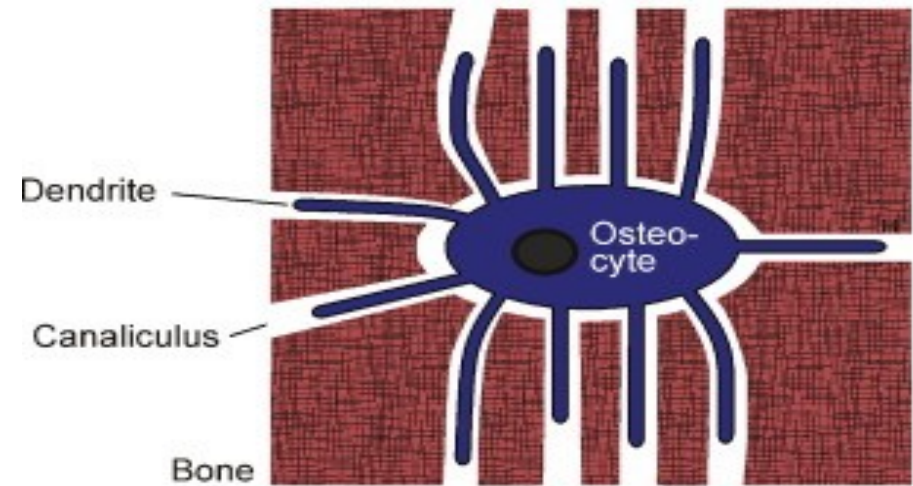
- a-Show high alkaline phosphatase activity
- b-Have a well-developed r ER and Golgi complex
- c-Synthesize and secrete all the organic components of the matrix
- ☒ d-Connected to each other by tight junction

### 3) Osteocytes:

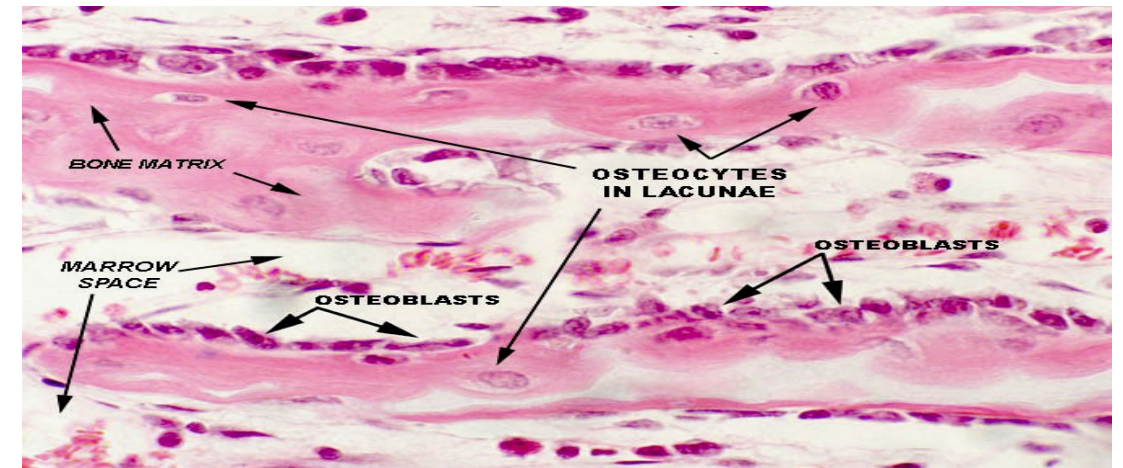
**Origin:** osteoblasts become surrounded by the material they secrete and differentiate as **osteocytes** enclosed **singly** within the **lacunae**.

#### **LM**

- **Shape:** oval branched cells with cytoplasmic processes that pass in small canaliculi
- **Cytoplasm:** pale basophilic
- **Nucleus:** central, oval and deeply stained



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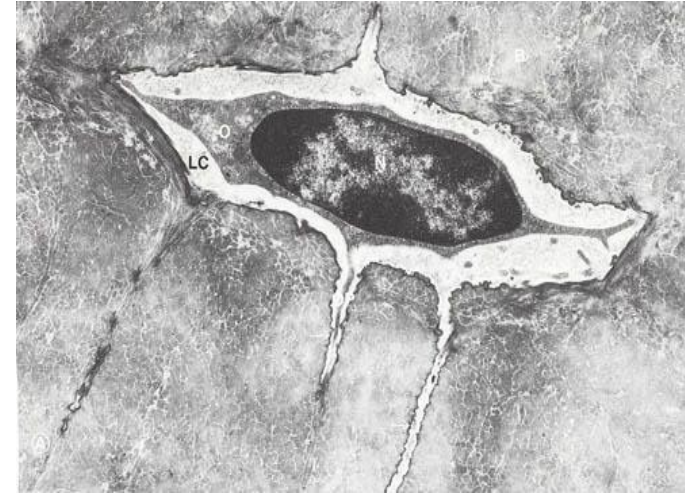


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## **E.M:**

- rER, ribosomes, Golgi complex, and mitochondria.
  - Cytoplasmic processes of one cell joined to other cells by **Gap junction** to allow passage of electrolytes between cells
- Function:**  
(mechanosensory).



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Osteocytes maintain the calcified matrix and their death is followed by rapid matrix resorption.

**Fate:** it does not have the ability to divide (end cell)



# Medical Applications



- The network of osteocyte processes and other bone cells is called a “mechanostat”. It monitors mechanical loads in bones and signals cells to adjust ion levels and maintain bone matrix. **Exercise** produces **increased bone density** and thickness, while lack of exercise leads to **decreased bone density**.

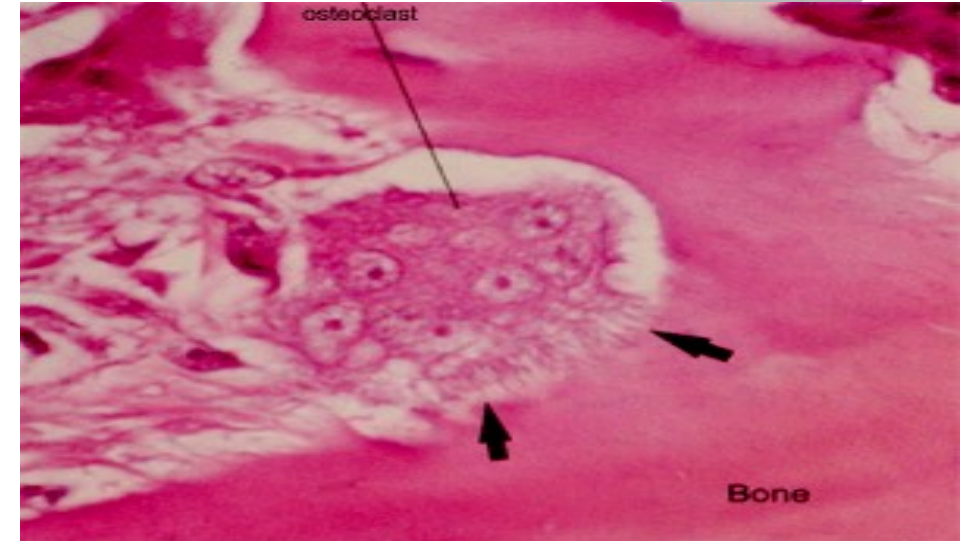
## 4) Osteoclasts

**Origin:** Fusion of bone marrow derived monocytes.

**Site:** on bone surface where bone resorption takes place. It lies in depressions in the matrix known as **resorption lacunae (Howship lacunae)**.

### **LM:**

- **Shape:** Very large irregular motile cell
- **Cytoplasm:** foamy **acidophilic** with striated (brush) border facing the bone surface.
- **Nucleus:** **multiple nuclei** (up to 50 nuclei)



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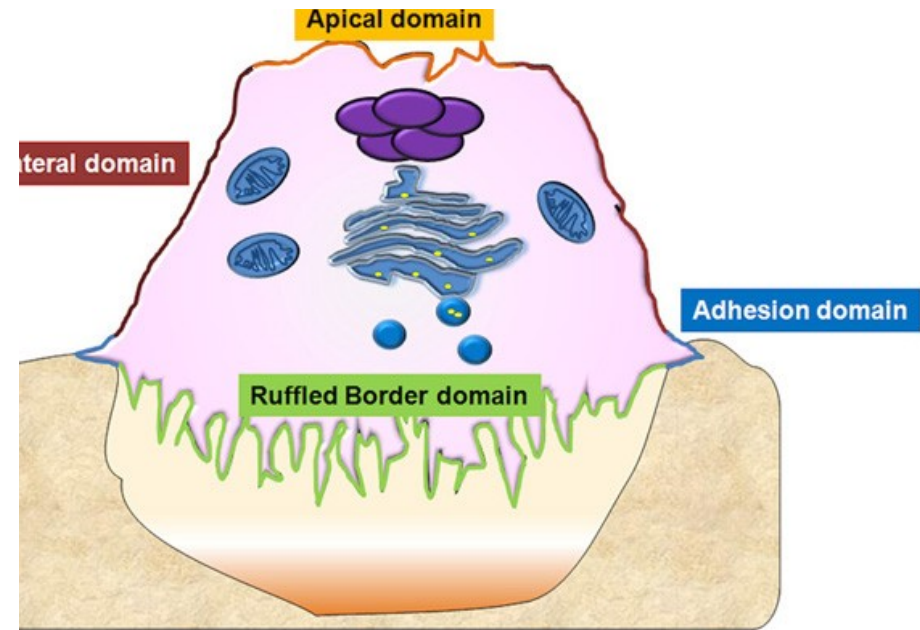


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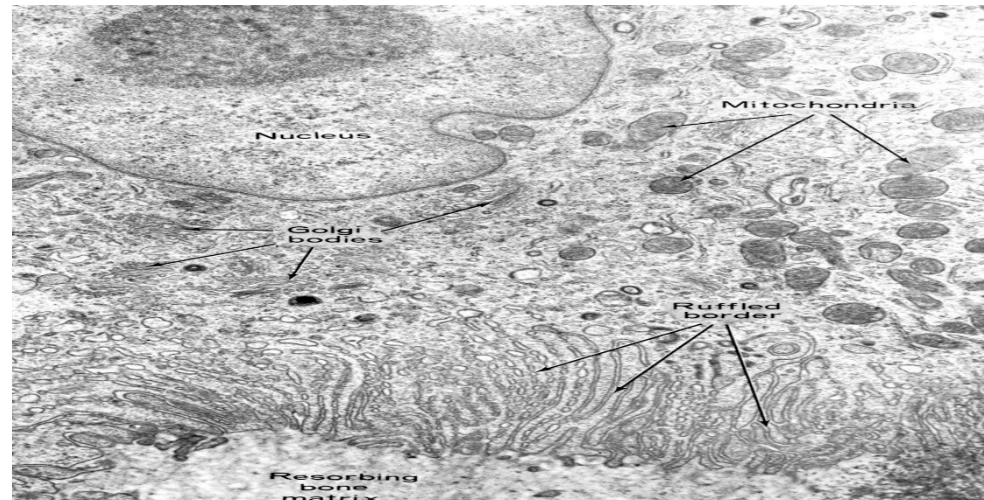
## **E.M: Three zones are distinguished :**

### ***1) Ruffled border zone:***

surface projections facing the bone surface and contains proton pump



<https://www.bioscience.org/2012/v4e/af/543/fig5.jp9>

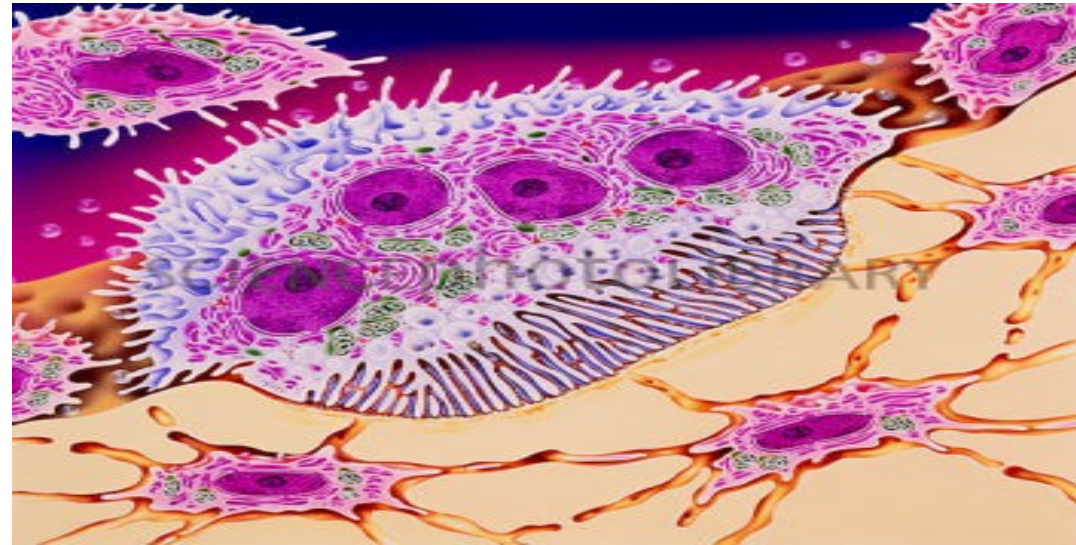


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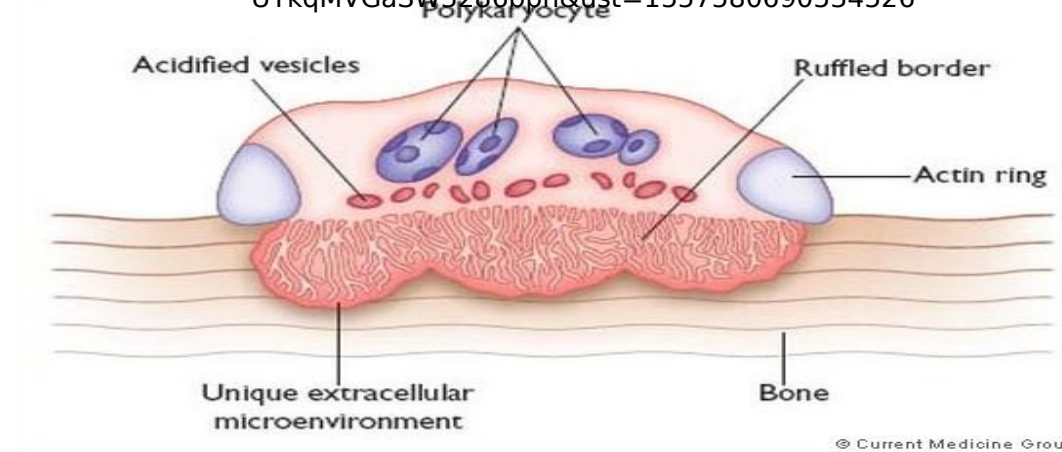


## 2) Sealing (Clear) zone:

- Binds the cell tightly to the bone matrix.
- It contains **actin filaments** arranged in a ring-like structure.
- The plasma membrane at the site of the clear zone contains **adhesion molecules** to provide a tight seal between the plasma membrane and mineralized matrix of the bone.



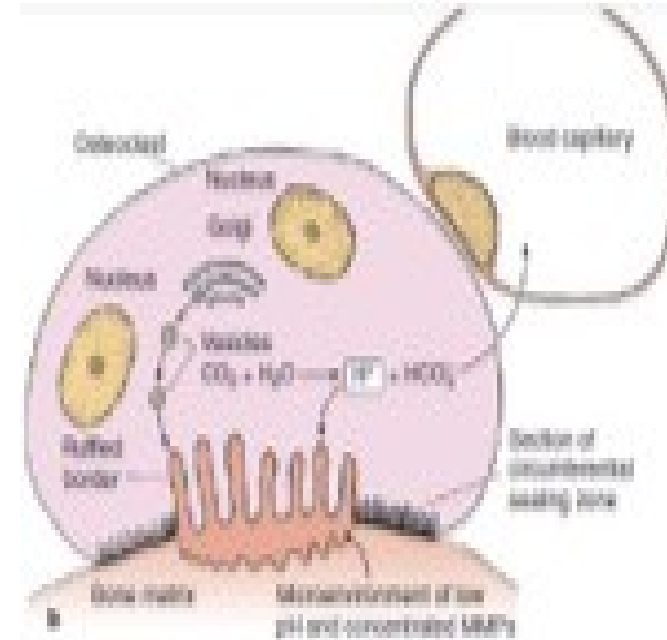
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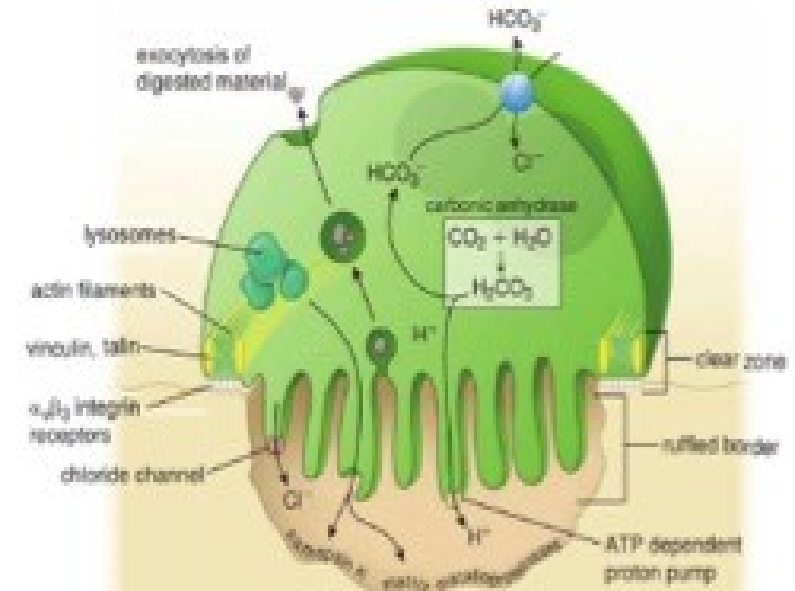
**3) Basolateral zone:** contain the nuclei and **many lysosomes:** Exocytosis of digested material occur from its surface.





## Function:

- ✓ Matrix resorption during bone growth and remodeling.
- ✓ **Osteoclasts resorb bone tissue by releasing protons and lysosomal hydrolases into the microenvironment of the extracellular space to dissolve the hydroxyapatite crystals and digest the matrix proteins.**
- ✓ Then transport vesicles containing degraded bone material endocytosed at the ruffled border fuse with the cell membrane of the basolateral region to release their contents.



**Osteoblasts activated by parathyroid hormone produce M-CSF, RANKL, and other factors** that regulate the formation

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<b>Osteoclast</b>	<b>Osteoblast</b>	
<b>Stem cell in bone marrow</b>	<b>Osteogenic</b> cell in good O <sub>2</sub>	<b>Origin</b>
<b>Endosteum</b> only	Inner osteogenic layer of <b>periosteum</b> and in the <b>endosteum</b>	<b>Site</b>
Non branched cell with brush border toward bone surface	Branched cell	<b>Shape</b>
Acidophilic cytoplasm	Deeply basophilic with -ve Golgi image	<b>Cytoplasm</b>
Multiple nuclei	Single eccentric	<b>Nucleus</b>
3 zones: ruffled, clear, basolateral zones	RER, Golgi, mitochondria and matrix vesicles	<b>EM</b>
Bone resorption	Bone formation	<b>Function</b>



<b>Osteocytes</b>	<b>Chondrocytes</b>	
Osteoblast	Chondroblast	<b>Origin</b>
Oval	Oval or round	<b>Shape</b>
Branched	Not branched	<b>Cytoplasmic branches</b>
Present singly in lacunae	Present singly OR in groups in lacunae	<b>Number in lacunae</b>
Can't divide	Can divide	<b>Division</b>
No Interstitial growth in bone	Responsible for interstitial growth of cartilage	<b>Function</b>





## Osteopetrosis

Genetic disease characterized by **lack of ruffled border of osteoclast**  
causing defect in **bone resorption** → **increase in thickness of bone**  
**narrowing of bone marrow spaces** → **decrease in blood**  
**cells formation** → **decrease in red blood corpuscle** → **anaemia**



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# Osteoporosis:



- It is caused by estrogen deficiency (postmenopausal), immobilization, corticosteroids and smoking.
- Bone resorptions exceed bone formation resulting in decreased thickness of bone



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# Lecture Quiz



## -Bony canaliculi are defined as :

- a-Connection between Haversian canals
- b-Cytoplasmic extensions from osteoblasts
- ☒ c-Channel like structure containing the processes of osteocytes
- d-Bony trabeculae

## - Osteoclasts:

- a) Are small immotile cells
- ☒ b) Have multiple nuclei
- c) Have deep basophilic cytoplasm
- d) Are present in lacunae inside bone matrix

## Key Points



- Microscopic structure & function of different types of bone cells (osteogenic, osteoblasts, osteocytes & osteoclasts).
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- Differentiate between chondrocytes & osteocytes.
- Diseases which affect bone.

# Summary

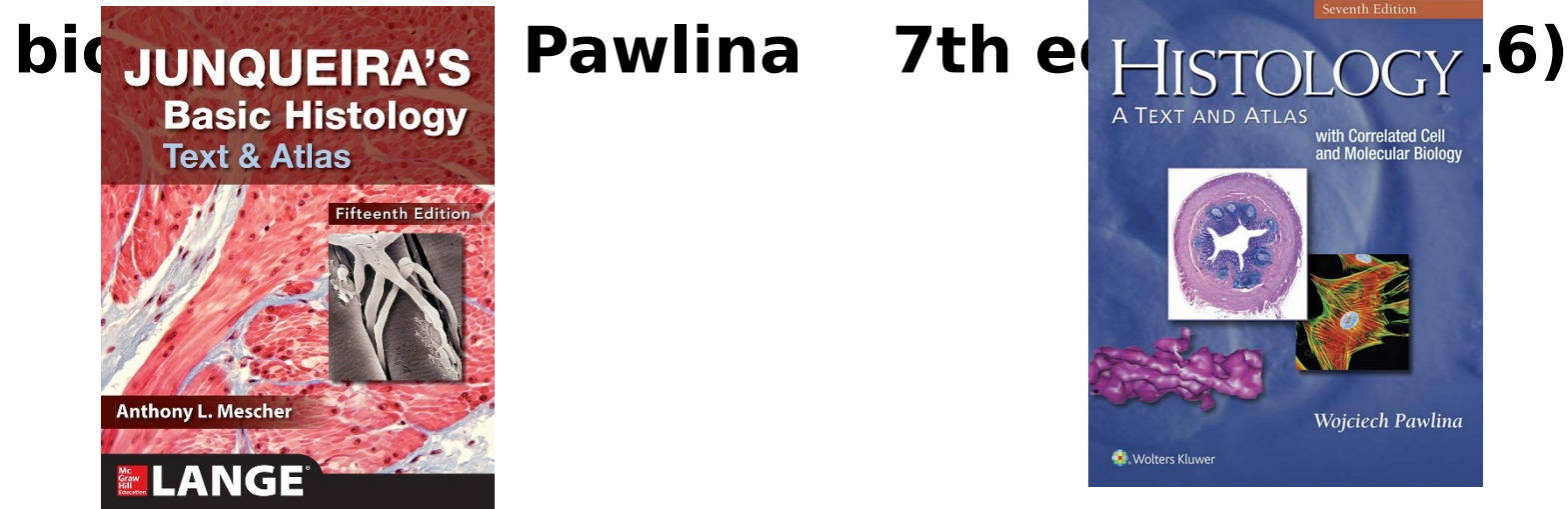


1. Bone is a special type of C.T. with stony hard matrix
2. Bone cells are: osteogenic, osteoblast, osteocyte and osteoclast
3. Osteogenic cells are the stem cells of bone
4. Osteoblasts are the bone forming cells and are not present in lacunae
5. Osteoclasts are the bone resorbing cells
6. By EM the osteoclast has four zones; from the bone surface they are ruffled border, clear zone, vesicular zone and basal zone

# SUGGESTED TEXTBOOKS



- 1. Junqueira's Basic Histology: Text and Atlas, 15th Edition by Anthony Mescher (2018)**
- 2. Histology a text and atlas with correlated cell and molecular**



THANK  
YOU

